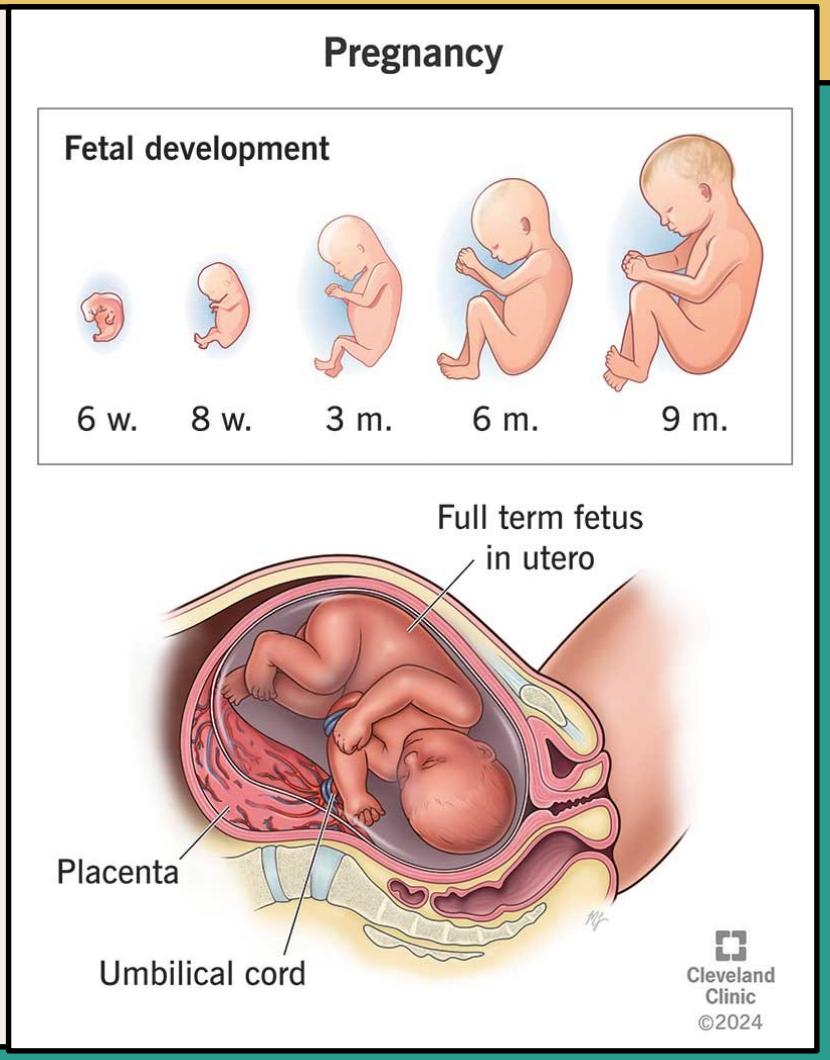
PHYSIOLOGICAL CHANGES IN PREGNANCY



GENITAL ORGANS

VULVA: Vulva becomes edematous and more vascular; superficial varicosities may appear especially in multiparae. Labia minora are pigmented and hypertrophied.

VAGINA: Vaginal walls become hypertrophied, edematous and more vascular. Increased blood supply of the venous plexus surrounding the walls gives the bluish coloration of the mucosa **(Jacquemier's sign)**. The length of the anterior vaginal wall is increased.

***Secretion*:** The secretion becomes copious, thin and curdy white due to marked exfoliated cells and bacteria. The pH becomes acidic (3.5–6) due to more conversion of glycogen into lactic acid by the *Lactobacillus acidophilus* consequent on high estrogen level. The acidic pH prevents multiplication of pathogenic organisms.

***Cytology*:** There is preponderance of **navicular cells in cluster** (small intermediate cells with elongated nuclei) and plenty of lactobacillus

The uterus which in nonpregnant state weighs about 60 g, with a cavity of 5–10 mL and measures about 7.5 cm in length, **at term**, **weighs 900–1,000 g and measures 35 cm in length**. The capacity is increased by 500–1,000 times. Changes occur in all the parts of the uterus—body, isthmus and cervix.

BODY OF THE UTERUS: There is increase in growth and enlargement of the body of the uterus. ***Enlargement*:** The enlargement of the uterus is affected by the following factors:

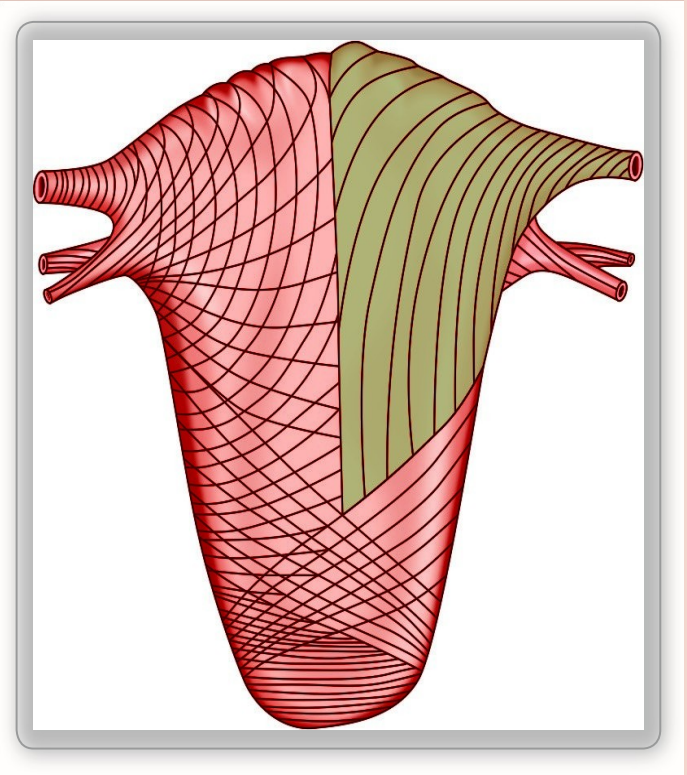
- **Changes in the muscles**—(1) **Hypertrophy and hyperplasia**. These occur under the influence of the hormones—estrogen and progesterone.
- (2) **Stretching**: Th e muscle fibers further elongate beyond 20 weeks due to distension by the growing fetus. The wall becomes thinner and, at term, measures about 1.5 cm or less. Th e uterus feels soft and elastic.

Arrangement of the muscle fibers: Three distinct layers of muscle fibers are evident:

1) **Outer longitudinal**—It follows a hood-like arrangement over the fundus.
2) (2) **Inner circular**—It is scanty and sphincter like arrangement around the tubal orifices and internal os.

(3) **Intermediate**—It is the thickest and strongest layer arranged in crisscross fashion through which the blood vessels run. n **There is simultaneous increase in number and size** of the supporting fibrous and elastic tissues.

The uterine enlargement is not a symmetrical one. **The fundus enlarges more than the body**.

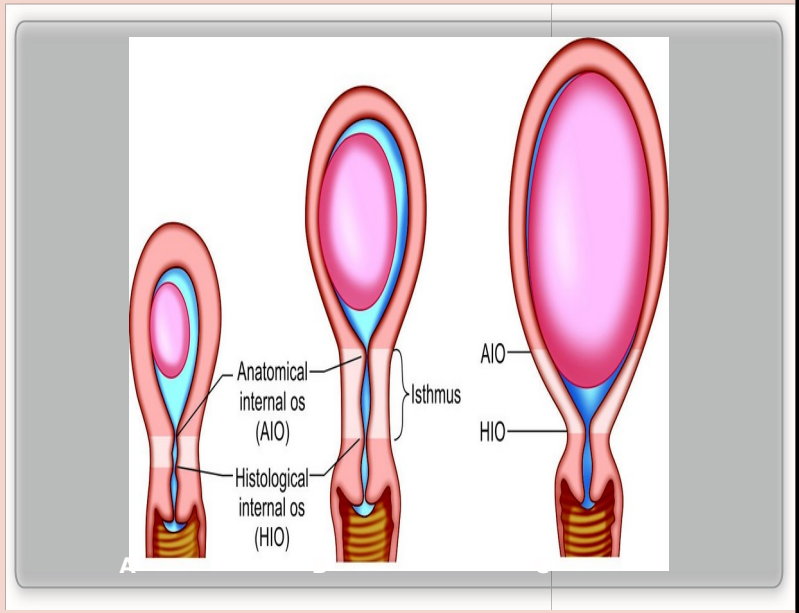


CERVIX

Uterine contraction in pregnancy has been named after *BraxtonHicks* who first described its entity during pregnancy

softening of the cervix (Goodell's sign)

The contractions are irregular, infrequent, spasmodic and painless without any effect on dilatation of the cervix.



ISTHMUS

There are important structural and functional changes in the isthmus during pregnancy.

During the first trimester, isthmus hypertrophies and elongates to about 3 times its original length. It becomes softer. With advancing pregnancy beyond 12 weeks, it progressively unfolds from above, downward until it is incorporated into the uterine cavity.

BREAST

SIZE: Increased size of the breasts becomes evident even in early weeks. This is due to marked hypertrophy and proliferation of the ducts (estrogen) and the alveoli (estrogen and progesterone) which are marked in the peripheral lobules. The “**axillary tail**” (prolongation of the breast tissue under cover of the pectoralis major) becomes enlarged and painful.

NIPPLES AND AREOLA: The nipples become larger, erectile and deeply pigmented, the areola, become hypertrophied and are called **Montgomery’s tubercles**. Those are placed surrounding the nipples. Their secretion keeps the nipple and the areola moist and healthy.

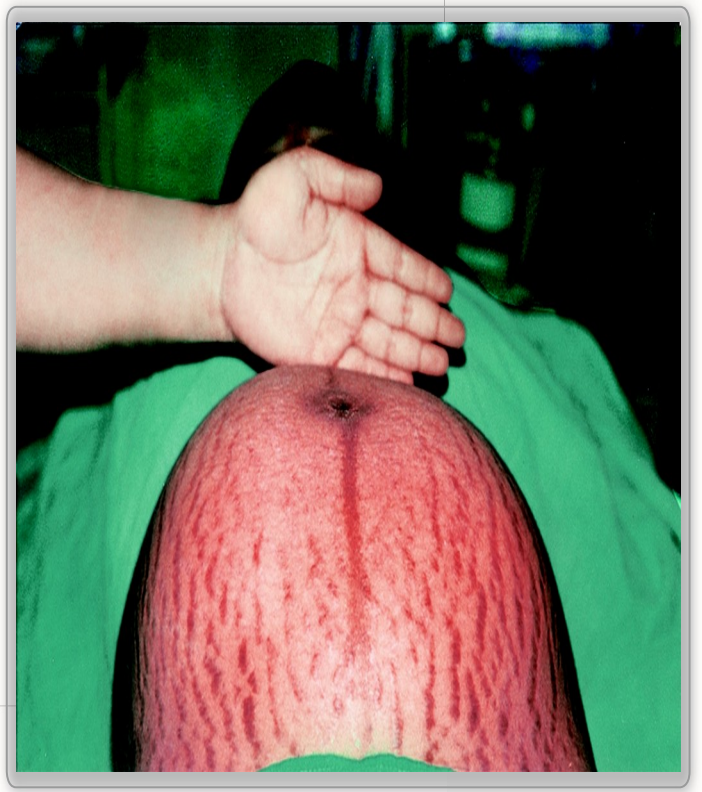
SECRETION: Secretion (colostrum) can be squeezed out of the breast at about 12th week which at first becomes sticky. Later on, by 16th week, it becomes thick and yellowish. **The demonstration of secretion from the breast of a woman who has never lactated is an important sign of pregnancy**..

CUTANEOUS CHANGES

PIGMENTATION: The distribution of pigmentary changes is selective.

- ***Face***
- (chloasma gravidarum or pregnancy mask): It is an extreme form of pigmentation around the cheek, forehead and around the eyes. It may be patchy or diffuse; disappears spontaneously after delivery.
- ***Abdomen*:**

1. **Linea nigra:** It is a brownish black pigmented area in the midline stretching from the xiphisternum to the symphysis pubis The pigmentary changes are probably due to **melanocyte stimulating hormone** from the anterior pituitary.
2. **Striae gravidarum**. These stretch marks represent the scar tissues in the deeper layer of the cutis. Initially, these are pinkish but after the delivery, the scar tissues contract and obliterate the capillaries and they become glistening white in appearance and are called **striae albicans**.



OTHER CUTANEOUS CHANGES: These include **vascular spider** and **palmar erythema** which are due to high estrogen level. Mild degrees of hirsutism may be observed and in puerperium the excess hair is lost.

WEIGHT GAIN

- REPRODUCTIVE WEIGHT GAIN : 6Kg

- Uterus—0.9 kg and breasts—0.4 kg
- Accumulation of fat (mainly) and protein—3.5 kg

- Increase in blood volume—1.3 kg

- Increase in extracellular fluid—1.2 kg

- **The amount of water retained during pregnancy at term is estimated to be 6.5 litres.**
- Weight gain for a woman with normal BMI (20–26) is 11–16 kg.

BODY WATER METABOLISM

- During pregnancy, the amount of **water retained at term is about 6.5 liters**. The water content of the fetus, placenta and amniotic fluid is about 3.5 liters.
- **Pregnancy is a state of hypervolemia.. The important causes of sodium retention and volume overload are:**
- (i) changes in maternal osmoregulation, (ii) increased estrogen and progesterone, (iii) increase in renin-angiotensin-aldosterone system (RAAS) activity, (iv) increased aldosterone, deoxycorticosterone, (v) control by arginine vasopressin (AVP) from posterior pituitary and (vi) atrial natriuretic peptide. Serum sodium level and plasma osmolality decreases. **There is resetting of the osmotic thresholds for thirst and AVP (ADH) secretion. Increase in water intake due to lowered osmotic threshold for thirst causes polyuria in early pregnancy**. The threshold for AVP secretion has been reset after 8 weeks for a new steady state of osmolality. Thereafter polyuria decreases.

- **Atrial and brain natriuretic peptides**, secreted by atrial myocytes and brain ventricles. These act as diuretics, natriuretics and vasorelaxants. Both the peptides are antagonist to RAAS.

Table: Principal Blood Changes during Pregnancy

Parameters	Nonpregnant	Pregnancy	Near Term	Total Increment	Changes
Blood volume (mL)	4000	5500	1500	+ 30–40%	
Plasma volume (mL)	2500	3750	1250	+ 40–50%	
Red Cell volume (mL)	1400	1750	35	+ 20–30%	
Total Hb (g)	475	560	85	+ 18–20%	
Hematocrit (whole body)	38%	32%	No change	Diminished	

Table 5.3: Changes in Blood Coagulation Factors

Parameters	Nonpregnant	Pregnancy near term	Change
Platelets (mm^3)	1,60,000–2,00,000	Conflicting observation	Static or 15% reduction of the count
Fibrinogen (mg%)	200–400	300–600	+50%
Fibrinolytic activity	—	Depressed	—
Clotting time	—	Unaffected	—

Table 5.2: Plasma Protein Changes during Pregnancy

Parameters	Nonpregnant	Pregnancy near term	Change
Total protein (g)	180	230	Increased
Plasma protein concentration (g/100 mL)	7	6	Decreased
Albumin (g/100 mL)	4.3	3	Decreased (30%)
Globulin (g/100 mL)	2.7	3	Slightly increased

CARDIOVASCULAR SYSTEM

Table 5.4: Hemodynamic Changes during Pregnancy

Parameters	Nonpregnant	Pregnancy near term	Change
Cardiac output (L/min)	4.5	6.26	+ 40%
Stroke volume (mL)	65	75	+ 27%
Heart rate (per minute)	70	85	+ 17%
Blood pressure	Unaffected or mid-pregnancy drop of diastolic pressure by 5–10 mm Hg		
Venous pressure	10 cm (femoral)	20–25 cm water	+ 100%
Colloid oncotic pressure (mm Hg)	20	18	– 14%

SUPINE HYPOTENSION SYNDROME (POSTURAL HYPOTENSION): During late pregnancy, the gravid uterus produces a compression effect on the inferior vena cava when the patient is in supine position. This, however, results in opening up of the collateral circulation by means of paravertebral and azygos veins. In some cases (10%), when the collateral circulation fails to open up, the venous return of the heart may be seriously curtailed. This results in production of hypotension, tachycardia and syncope. **The normal blood pressure is quickly restored by turning the patient to lateral position.** The augmentation of the venous return during uterine contraction prevents the manifestation from developing during labor.

REGIONAL DISTRIBUTION OF BLOOD FLOW: Uterine blood flow is increased from 50 mL/min in nonpregnant state to about 750 mL near term. Nonpregnant uterus receives 2% of CO and breasts 1%. Increase in blood flow going to the organs is about 50% due to overall increase in CO. The increase is due to the combined effect of uteroplacental and fetoplacental vasodilatation The **vasodilatation** is due to the smooth muscle relaxing effects of progesterone, estrogen, nitric oxide (endothelium derived factor), prostaglandins and atrial natriuretic peptide (ANP). In a normal pregnancy, vascular system becomes refractory to angiotensin II, endothelin I and other pressure agents .**Pulmonary blood flow** (normal 6,000 mL/min) is increased by 2,500 mL/min. **Renal blood flow** (normal 800 mL) increases by 400 mL/min at 16th week and remains at this level till term. **The blood flow through the skin and mucous membranes** reaches a maximum of 500 mL/min by 36th week. **Heat sensation, sweating or stuffy nose complained by the pregnant women can be explained by the increased blood flow**.

Table 5.6: Changes in Respiratory System

Parameters	Nonpregnant	Pregnancy near term	Change
Respiration rate/min	15	15	Unaffected
Vital capacity (mL)	3200	3300	Almost unaltered
Tidal volume (mL)	475	675	+ 40%
Residual volume (mL)	965	765	– 20%
Inspiratory capacity (IC)	2500	2650	+10%
Minute ventilation	7.5 L/min	10.5 L/min	+40%
Total lung capacity (mL)	4200	4000	–5%

Table 5.5: Changes in Lipid Metabolism

Parameters	Nonpregnant	Pregnancy near term	Change
Total lipid (mg/100 mL)	650	1000	+ 50%
LDL and Cholesterol (mg/100 mL)	180	260	+ 40%
HDL (mg/100 mL)	60	70	+ 15%
Triglycerides (mg/100 mL)	80	160	+ 50%

- **Pregnancy is in a state of respiratory alkalosis.**
- **Renal plasma flow** is increased by 50–75%.
- **Glomerular filtration rate (GFR)** is increased by 50% all throughout pregnancy.
- Marked hypertrophy of the muscle and the sheath of the ureter especially the pelvic part probably due to estrogen. **There is elongation, kinking and outward displacement of the ureters.**
- **Daily requirement of calcium during pregnancy and lactation averages 1–1.5 g. Maternal total calcium levels fall but serum ionized calcium level is unchanged.**
- Calcium absorption from intestine and kidneys are doubled due to **rise in the level of 1, 25 dihydroxy vitamin D_3.**
- Calcitonin levels increase by 20%.

Table 5.7: Acid-Base Changes

Parameters	Nonpregnant	Pregnancy near term	Change
Arterial PO_2	95 mm Hg	106 mm Hg	Increased
Arterial PCO_2	38 mm Hg	32 mm Hg	Diminished
pH	7.40	7.42	Slightly increased
Plasma HCO_3	26 m mol/L	22 mmol/L	Decreased

Thank you